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SURFACE ROUGHNESS MEASUREMENT ON AL-7075 REINFORCED WITH THE ZRO_2 POWDER BY USING BOX-BEHNKEN ANALYSIS

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ABSTRACT

In the present study, the surface roughness characteristics of Al-7075 require analysis due to the abrasive phase present in the reinforcement of Zro_2 particles. So the presence of nano particles in the metal increases hardness and strength. When the workpiece is machined, discontinuous chips are produced, resulting in different machining characteristics. So, by using surface roughness tester, the measured values are seen and by box-behnken analysis the various parameters are found.

KEYWORDS: Surface Roughness Measurement (Talysurf Instrument), Box-Behnken & Design Analysis

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Original Article

INTRODUCTION

Introduction to Surface Roughness for Al-7075 and Zro_2

Gradually, increase in the distance at lower cutting speeds, with HSS tools machining $AlZro_2$ MMCs, surface roughness (Ra). The work material is diffused to the tool surface and then abraded, at high cutting speeds. Later, it detached back from the tool to the machined surface and thus induced to many of surface defects with the increase in Ra values.

The coolant was to control the diffusion effect, to improve surface quality. Wear on the tool translated into replication of the ridges on the machined surface also observed at lower speeds, imparting higher surface roughness. Lin et al. reported that surface finish improved with the increased cutting speeds at constant feed rate.

So, the surface finish was obtained with a slightly worn tool due to stability of the nose radius. Similarly, results were obtained for surface finish with feed while machining Al/Zro_2 (20p) MMCs by Venkatesh et al [1]. During turning of LM 10 $AlZro_2$, the feed is the most significant parameter affecting surface roughness.

Talysurf Instrument

“TALYSURF ROUGHNESS TESTER”, the instrument which measures the surface roughness is used which shows the Ra values of machined work pieces.

Figure 1: Surface Roughness Tester

Machine, Tool Used, and Material and Experimental Methods

Machine

The dry turning operation is carried out using a medium duty lathe with following specifications:

- Distance between centres
- Main spindle power
- Feed type: Cross and longitudinal
- Drive system: Gear
- Head stock: 3 jaw chuck

Cutting Tool Inserts

For the dry turning of hybrid MMC material, HSS is chosen after doing a quick review (Table 3) over different grades of the HSS tool

Table 1: Specification of the Tool Holder and HSS Insert

Characteristics	Specifications
Substrate	High speed steel
Insert HSS	
Nose radius	2mm – 4mm
Shank size	1.5
Tool holder specification	
Product name	

Material

With the present investigation of (Al-7075) with particle reinforcements of Zro_2 5% and 10%, the grain size varied from 20 nm to 50 nm. This composite material is fabricated in the form of cylindrical rods of diameter 25 mm and length 100 mm. The rod is manufactured in- house by stir-casting process.

METHODOLOGY

Box-Behnken Method Procedure

For this experiment, Box-Behnken method is designed to deal with responses influenced by number of variables. In this method, main parameters are assumed to have influence on process results, which are located at different rows in a designed orthogonal array (L-10). This method is useful for studying the interactions between the parameters that provides a simple, efficient and systematic approach to determine optimal cutting parameters. In comparison to the conventional approach of experimentation, this method reduces drastically the number of iterations that are required to model the response functions. The analysis of variance is performed to find the significant parameters.

Experimental Details

Using Box-Behnken orthogonal array, the parameters are done in the design of experiments (DoE), which helps in reducing the number of iterations. The three cutting parameters are selected as cutting speed (v), feed (f) and depth of cut (d). It has been decided to use three level tests (Table 7) for each factor. Box-Behnken orthogonal array of L10 is the most suitable for these parameters.

Table 2:Chemical Composition of Aluminium Alloy (Al-7075) T6511 Matrix

Element	%Weight	Element	% Weight
Si	0.4	Cr	0.28
Cu	2.0	N	-
Mg	2.9	Zn	6.1
Mn	0.3	Ti	0.2
Fe	0.5	Zr	-

Table 3: Parameters and Three Levels

Control Parameters	Unit	Symbol	Levels		
			1	2	3
Cutting speed	mm/min	v	19	30	47
Feed rate	mm/rev	f	0.53	0.58	064
Depth of cut	mm	d	0.3	0.6	0.9

Effect of Control Parameters on Surface Roughness

In Box-Behnken design method, the three (3) control parameter indicates the numbers of trials and R1, R2, R3 are the observed values. It is the fact that, an increase in feed increases the heat generation and tool wear. Also, the increase in feed also increases the chatter, and it produces incomplete machining of work piece, which leads to higher surface roughness. Based on the above discussions, the optimum conditions for the surface roughness could be established.

Box-Behnken Design for the Control Parameters

In this method based on control parameters, the required analysis is done to get the design summary and design table.

Table 4: Design Values

Factors	3	Replicates	1
Base runs	15	Total runs	15
Base blocks	1	Total blocks	1

Table 5: Design Table

Run	BLK	A	B	C
1	1	-1	-1	0
2	1	1	-1	0
3	1	-1	1	0
4	1	1	1	0
5	1	-1	0	-1
6	1	1	0	-1
7	1	-1	0	1
8	1	1	0	1
9	1	0	-1	-1
10	1	0	1	-1
11	1	0	-1	1
12	1	0	1	1
13	1	0	0	0
14	1	0	0	0
15	1	0	0	0

Response Surface Regression: Response (Q_e) Verses Cutting Speed, Depth of Cut and Feed Rate

Table 6: Coded Coefficients

S. NO	Term	Coefficients	SE Coefficient	T-value	P-value	VIF
1	Constant	0.3580	0.0309	11.57	0.00	
2	Cutting speed	0.0640	0.0245	2.62	0.035	1.00
3	Feed rate	0.0175	0.0245	0.72	0.497	1.00
4	Depth of cut	-0.0985	0.0245	-4.03	0.005	1.00
5	Cutting speed*cutting speed	-0.0339	0.0337	-1.00	0.348	1.01
6	Feed rate*Feed rate	0.0006	0.0337	0.02	0.986	1.01
7	Depth of cut*Depth of cut	0.0806	0.0337	2.39	0.048	1.01
8	Cutting speed*Feed rate	0.0303	0.0346	0.87	0.411	1.00
9	Cutting speed*Depth of cut	-0.0497	0.0346	-1.44	0.194	1.00
10	Feed rate*Depth of cut	0.0948	0.0346	2.74	0.029	1.00

Table 7:Analysis of Variance

S. NO	Source	Df	Adj SS	Adj MS	F-Value	P-Value
1	Model	9	0.193428	0.021492	4.49	0.030
2	Linear	3	0.112836	0.037612	7.86	0.012
3	Cutting speed	1	0.032768	0.032768	6.85	0.035
4	Feed rate	1	0.002450	0.002450	0.51	0.497
5	Depth of cut	1	0.077618	0.077618	16.22	0.005
6	Square	3	0.031121	0.010374	2.17	0.180
7	Cutting speed*Cutting speed	1	0.004832	0.004832	1.01	0.348
8	Feed rate*Feed rate	1	0.000002	0.000002	0.00	0.986
9	Depth of cut*Depth of cut	1	0.027370	0.027370	5.72	0.048
10	2-way interaction	3	0.049471	0.016490	3.45	0.081
11	Cutting speed*Feed rate	1	0.003660	0.003660	0.76	0.411
12	Cutting speed*Depth of cut	1	0.009900	0.009900	2.07	0.194
13	Feed rate*Depth of cut	1	0.035910	0.035910	7.50	0.029
14	Error	7	0.033500	0.004786		
15	Lack-of-fit	3	0.028234	0.009411	7.15	0.044
16	Pure error	4	0.005266	0.001316		
17	Total	16	0.226928			

RESULTS

Contour and Surface Plots Related to Box-Behnken Design

Contour Plot for Response (Qe) Vs Cutting Speed, Feed Rate

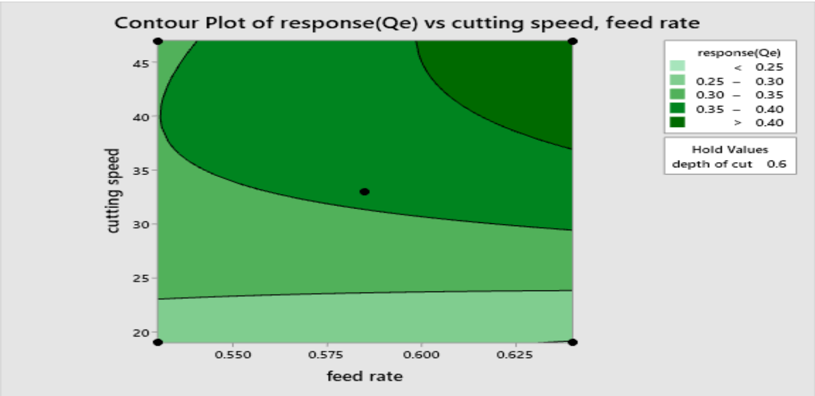

Figure 2: Contour Plot for Response (Qe) Vs Cutting Speed, Feed Rate.

Contour Plot for Response (Qe) Vs Cutting Speed, Depth of Cut

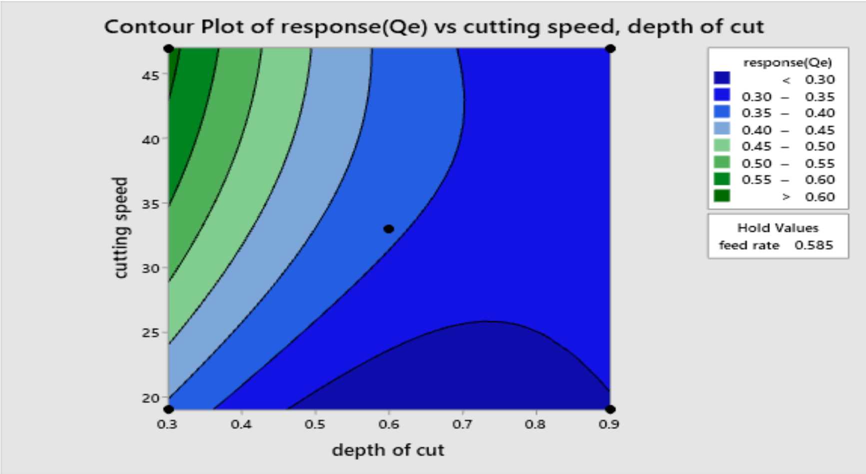

Figure 3: Contour Plot for Response (Qe) Vs Cutting Speed, Depth of Cut.

Contour Plot for Response (Qe) Vs Feed Rate, Depth of Cut

Figure 4: Contour Plot for Response (Qe) Vs Feed Rate, Depth of Cut.

Surface Plots

Surface Plot for Response (Qe) Vs Cutting Speed, Feed Rate

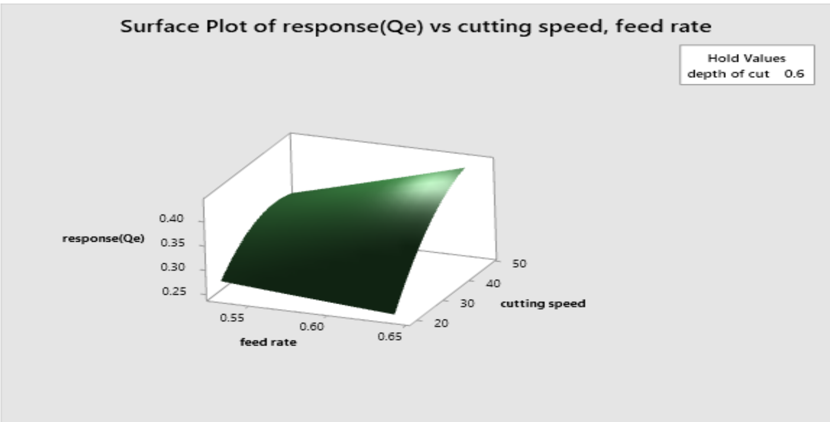

Figure 5: Surface Plot for Response (Qe) Vs Cutting Speed, Feed Rate.

Surface Plot for Response (Qe) Vs Cutting Speed, Depth of Cut

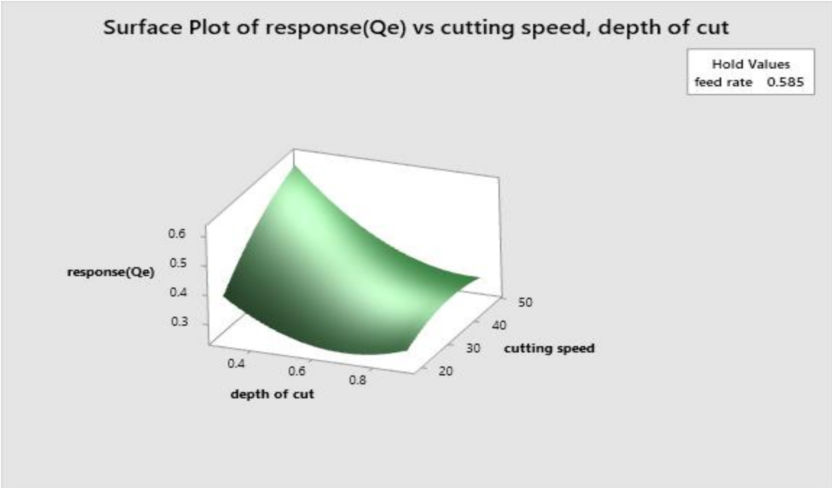

Figure 6: Surface Plot for Response (Qe) Vs Cutting Speed, Depth of Cut.

Surface Plot for Response (Qe) Vs Feed Rate, Depth of Cut

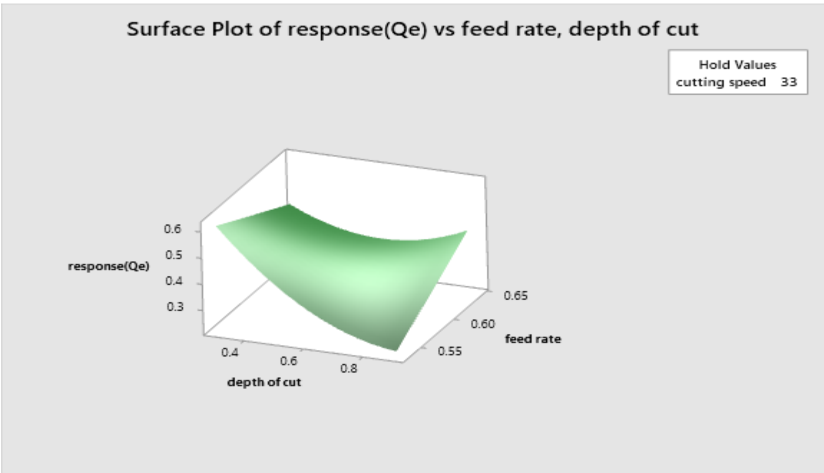

Figure 7: Surface Plot for Response (Qe) Vs Feed Rate, Depth of Cut.

Main Effect Plot for Response (Qe) with Feed Rate, Depth of Cut

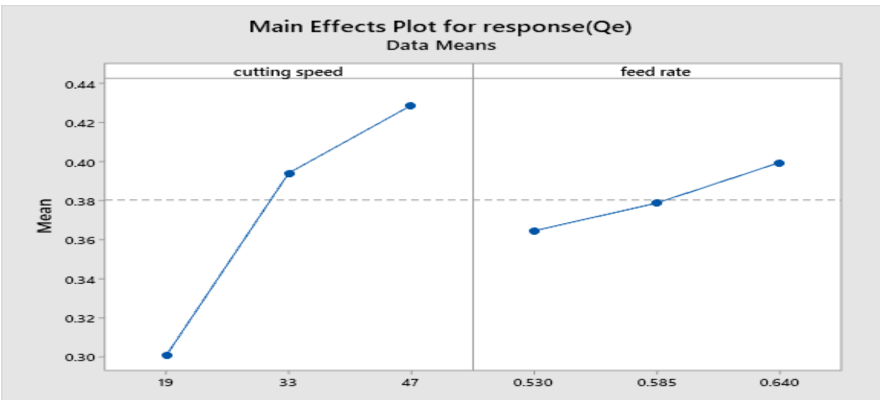

Figure 8: Main Effect Plot for Response (Qe) with Feed Rate, Depth of Cut.

Main Effect Plot for Response (Qe) with Cutting Speed

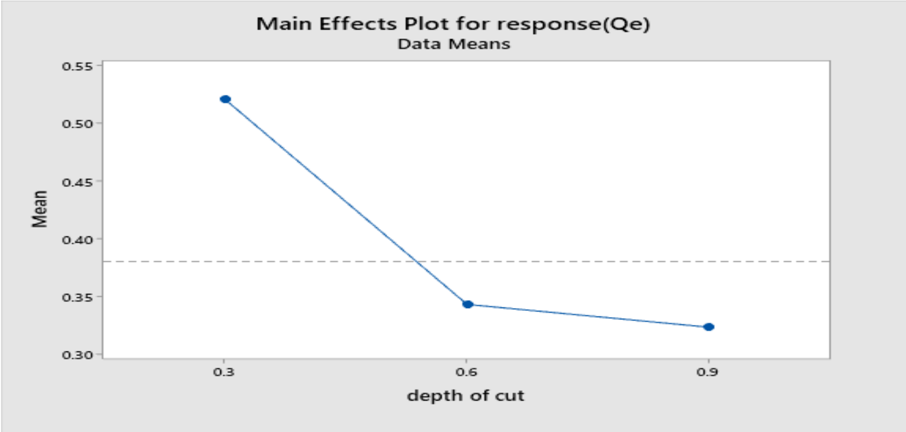

Figure 9: Main Effect Plot for Response (Qe) With Cutting Speed.

Probability Plot of Cutting Speed

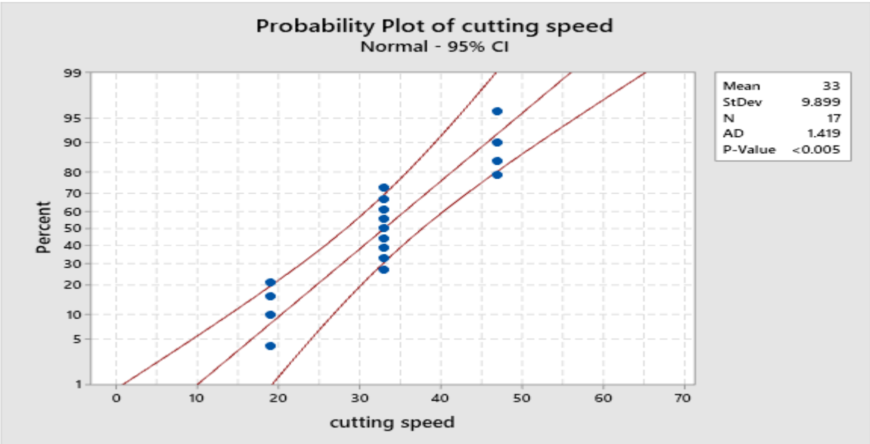

Figure 10: Probability Plot of Cutting Speed.

Probability Plot of Feed Rate

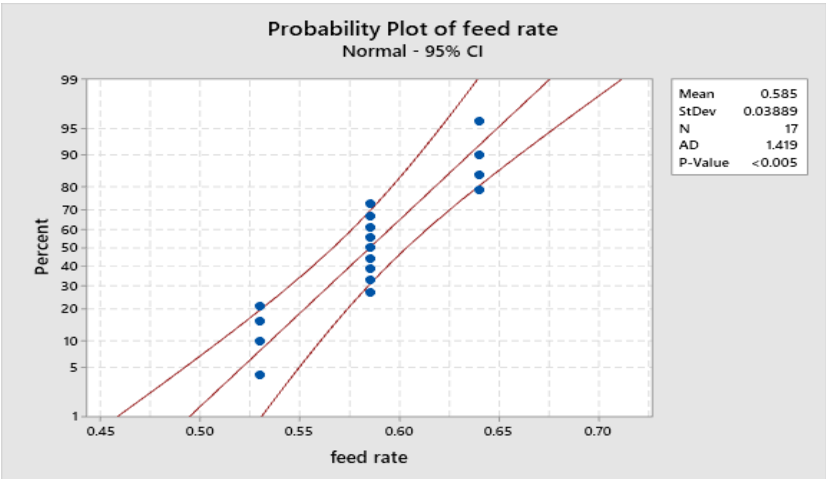

Figure 11: Probability Plot of Feed Rate.

Probability Plot of Depth of Cut

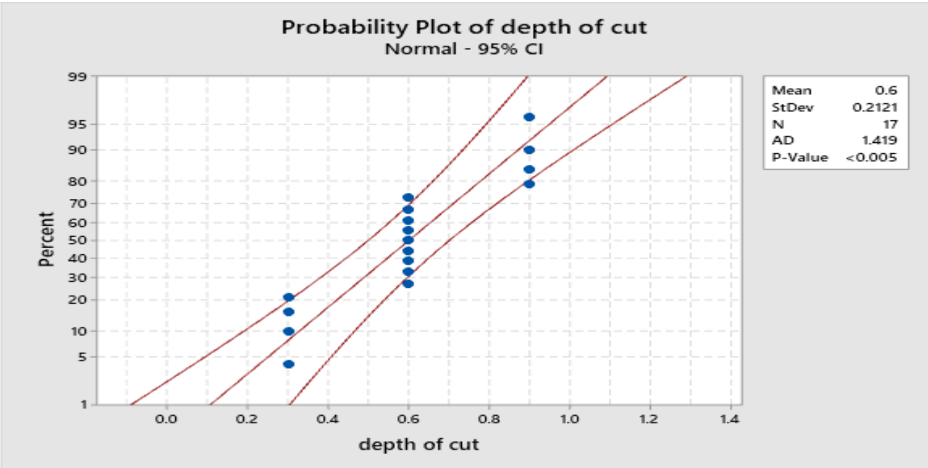

Figure 12:Probability Plot of Depth of Cut.

CONCLUSIONS

The surface roughness for machining of (Al-7075) with reinforcements of nano particles with 5%, 10% Zro_2 under different cutting conditions with a HSS tool of 1600 grade using Box-Behnken method is studied. Based on the experimental and analytical results, the following conclusions are drawn:

- With the help of Box-Behnken method, the effect of machining parameters on the surface roughness has been evaluated and optimal conditions are arrived to minimize the surface roughness.
- The depth of cut is the dominant parameter for surface roughness.

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